

Environmental characteristics of Kyparissiakos Gulf

4.1. Introduction

An extensive study has been carried out by the Defence Evaluation and Research Agency (DERA), Southampton Oceanography Centre, UK, on environmental characteristics of the Kyparissiakos Gulf, such as hydrographic, meteorological, climatological, geophysical, geochemical and sound propagation conditions, as well as tectonic activities and magnetic anomalies. Information was provided by:

- UK Hydrographic Office
- UK Meteorological Office
- British Geological Survey
- NATO RV *Alliance* logbooks and observations
- Hellenic Meteorological Service
- Hellenic Navy Hydrographic Office
- British Admiralty Pilot
- SACLANTCEN
- NAVOCEANO
- Fleet Weather Forecast Naples
- Rome Weather Forecast
- Kerkyra Radio Weather Forecast

Dr. A.D. Heathershaw and E.C. Devonshire supplied the following summary of the DERA information.

DERA has carried out an assessment of environmental conditions in Kyparissiakos Gulf in the period immediately preceding the reported strandings of Cuvier's beaked whales along the west Peloponnissos coastline. Attention has focused in particular on oceanographic and meteorological conditions in the period 15 April to 15 May 1996 with a view to establishing whether these were in any way unusual or whether there might be other extenuating circumstances which could have lead to the stranding of the whales. The terms of reference were:

- to examine the meteorological and oceanographic conditions at the time of the strandings together with other geophysical data
- to compare observations with historical records (i.e. climatology), to look for evidence of any anomalous environmental conditions
- to relate observed conditions to sonar propagation characteristics in the area at the time

- to determine whether natural physical or biogeochemical processes in the environment could have been a contributory factor in the observed strandings.

4.2. Regional context and setting

The specific area of interest is in the eastern Ionian Sea between Peloponnisos and the Island of Zakynthos. The area immediately offshore of Kyparissiakos Gulf is abutted by a relatively narrow continental shelf, the 200 m depth contour lying at distances of 5-10 km from the coast. Beyond this, water depths increase steadily reaching 1000 m at about 20-30 km from the coast. From an acoustics point of view, the slope and the ridge offshore of Kyparissiakos might be expected to contribute to high reverberation levels in this area. Tidal influences in the area are weak with a mostly semi-diurnal period throughout the region of interest. The Greek coastal front, lying at a distance of 75-100 km offshore of Kyparissiakos Gulf, could play a part in the eastern Mediterranean circulation and availability of nutrients and food for sea mammals in the region. During May it is likely that inflows to the southern part of Kyparissiakos Gulf, from the south and west, will be present, merging into a northern flow along the coast of Peloponnisos. A complex current system may therefore be set up where these two flows converge. The inflow from the south may diverge upon entering the Gulf, with one stream flowing NW towards Zakynthos and another passing along the Peloponnisos coast from south to north.

4.3. Meteorology

An examination of the conditions in the area in the month preceding the strandings at the UK Met Office and of the Naples, Rome and Kerkyra surface weather analyses and forecasts for the period 11 - 15 May 96, as well as observed conditions from NRV *Alliance* and other ships in the area at the time of the strandings resulted in following main findings:

- conditions in the 30 days or so prior to the strandings indicated alternating periods of SE and NW (but predominantly SE) winds, which at the southern end of the Gulf would have had an offshore component
- there were notably strong SE winds Force 6/7 on 30 Apr, 1 and 7 May 96
- observed conditions at the time of the strandings were consistent with forecast conditions from radio broadcasts
- a quasi-stationary front was situated over N Italy, which moved slowly E
- an extended Low Pressure system was located over the southern Adriatic and northern Ionian Seas extending E over the Aegean and Cretan Seas; a High Pressure system was located over the coasts of Libya and Egypt; the Low (ca. 1000 mbar) filled and moved NE towards the Balkans
- there was a cold unstable airstream over the Aegean
- forecast winds in S Ionian Sea for 11-15 May 96 were SW-NW, Force 4-6, occasionally Force 7
- thunder was also forecast for this period, but not observed by NRV *Alliance*

- during the period 4-10 May 96, winds were predominantly from a SE direction
- observations from NRV *Alliance* indicate slightly lower winds Force 2-4, occasionally Force 5
- forecast weather conditions and NRV *Alliance's* observations were in general corroborated by UK Met Office data and Voluntary Observing Ship programme observations.

4.4. Oceanographic Data

The main findings regarding sea water surface temperatures (SST), salinities, sound velocity profiles (SVPs) and currents were:

- Observed and predicted (climatological) seasonal water temperatures were in broad agreement; in the 15 days or so preceding the strandings, synoptic data indicate a quite rapid increase in SST from about 15.5°C on 30 Apr 96 to 17.5°C on 10 May and increasing further to 19.5°C on 20 May 96; such rapid rises are not uncommon in this area at this time of year and there is no evidence to suggest that this range of temperatures would adversely affect *Ziphius cavirostris*, the animals clearly encountering a far greater range of temperatures in their natural habitat.
- Hellenic sources show SST in Kyparissiakos Gulf in range 17.5°C to 18.0°C for May.
- NRV *Alliance* SST observations 11-13 May 96 were in the range 18.0°C to 19.0°C.
- UK Met Office ship observations (21) indicate a mean SST for the first half of May 96 of 17.8°C (note these are indicative of a larger area than NRV *Alliance's* observations).
- UK Hydrographic Office data (73 XBT observations) for period 1948-1989, for this time of year, indicate temperatures in a range 18.0-19.0°C at the surface (no mixed layer), falling to 15.0-16.0°C at 50-75 m depth, 15.0-16.0°C at 100 m and 14.5-15.0°C at 500 m; at 1000 m, temperatures have dropped to 13.7°C from CTD data.
- The waters in this area are characterized by low surface salinities, 38.55-38.60 PSU, increasing to 38.9 PSU at 200 m depth and then decreasing to 38.7 PSU at 1000 m.
- The effects of temperature and pressure are to create a shallow sound channel at depths of 50-75 m as shown by NRV *Alliance's* observations in the area in the period 12-13 May 96.
- For May, historical records indicate mean significant wave heights in the Ionian Sea in the range 0.8 - 1.0 m.
- It is possible that prevailing westerly winds and rough seas may have compounded the difficulties of Cuvier's beaked whales once stranded, but are not likely to have been a contributory factor in their arriving at the coast from any great distance offshore.

4.5. *Other environmental factors*

- In the period of interest, 15 April to 13 May 1996, the local Greek seismic monitoring network detected no significant earthquakes in the Kyparissiakos Gulf; a world database, however, shows the occurrence of 21 earthquakes with magnitudes 3.3 on the Richter scale in this area.
- Although it is known that some marine mammals have magnetite in their brains, the role of the magnetite is not clear. Nothing is known about the presence of such material in the brain of Cuvier's beaked whales. Available data suggest that there were no significant magnetic anomalies in the Kyparissiakos Gulf.

4.6. *Summary*

From a reasonably comprehensive analysis of the environmental data and other information from the Kyparissiakos Gulf region at the time of the stranding of Cuvier's beaked whales in May 1996, together with more recent observations, the following are the principal conclusions:

- There is no direct evidence of anomalous oceanographic or meteorological conditions at the time of the strandings or of other environmental factors which might have played a part.
- Seismic (i.e. sub-sea earthquakes) activity although present, is not likely to have been a contributory factor. Such events as were recorded were of low magnitude and in any case, seismicity is a persistent feature in this environment to which marine mammals may have already habituated.
- Lightning might have been a contributory factor - but there is little supporting evidence for this.
- Classified data sources and other information made available to Panel members, do not indicate the presence of significant magnetic anomalies in the Kyparissiakos Gulf area.
- Once in the vicinity of the shore, waves conditions (mass transport effects) could have held animals against the beach or rocks making it difficult for them to regain open water.
- On the basis of the evidence at our disposal, we are unable to conclude whether environmental conditions contributed directly to the strandings of Cuvier's beaked whales. While it is clear that conditions in the water column were able to support acoustic propagation to long ranges, water temperatures, salinities and sound velocity profiles were all consistent with the seasonal norm for the area.

Finally, we note that this analysis has been constrained by lack of information on precise conditions in the area at the time of the strandings. It is unlikely that we will ever know the precise sequence of events which led up to the animals being stranded.

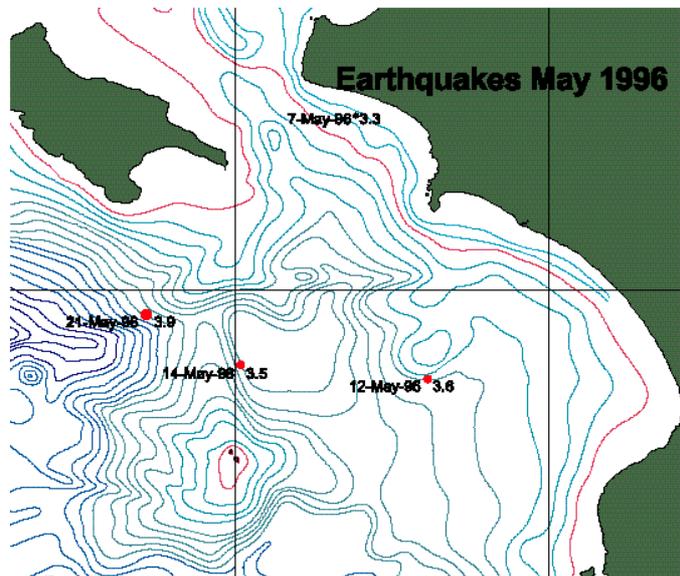


Figure 4.1. Earthquakes in the Kyparissiakos Gulf, in May 1996 (12 May 3.6 Richter scale; 14 May 3.5 Richter scale).

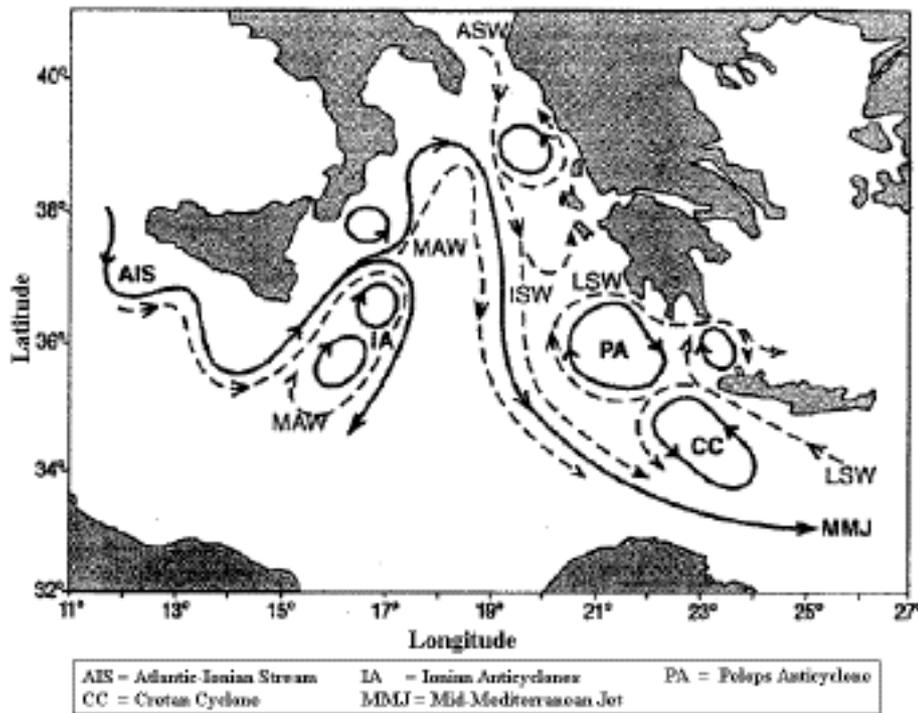


Figure 4.2. Schematic of the circulation and water mass pathways in different layers. Solid lines denote permanent dynamical feature, i.e. currents and sub-basin gyres. Dashed lines mark water mass pathways.